Module Name: **System Theory**					
Module Number		**Level**	Master	**Short Name**	
Module Responsibility	Prof. Dr. rer. nat. Thorsten M. Buzug				
Department, Facility	UzL, Institute of Medical Engineering				
Lecturers	Prof. Dr. rer. nat. Thorsten M. Buzug (Signals and Systems) Prof. Dr. rer. nat. Henrik Botterweck (Numerical Methods)				
Course of Studies	Medical Microtechnology, Master				
Compulsory/elective	Compulsory	**ECTS Credit Points**	6		
Semester of Studies	1	**Semester Hours per Week**	4		
Length (semesters)	1	**Workload (hours)**	180		
Frequency	WiSe	**Presence Hours**	48		
Teaching Language	English	**Self-Study Hours**	138		
Consideration of Gender and Diversity Issues	☒ Use of gender-neutral language (THL standard)				
	☐ Target group specific adjustment of didactic methods				
	☐ Making subject diversity visible (female researchers, cultures etc.)				
Applicability	Biomedical Engineering, Medical Microtechnology				
Remarks	None				

Course 1: Signals and Systems

Course Number		**Short Name**	SIGSYS
Course Type	Lecture	**Form of Learning**	Presence
Lecturer	Buzug		
Mandatory Attendance	☐	**ECTS Credit Points**	3
Participation Limit	120	**Semester Hours per Week**	2

Group Size (practical training, exercises, …)	None	**Workload (hours)**	90
Teaching Language	English	**Presence Hours**	24
Study Achievements („Studienleistung“, SL)	None	**Self-Study Hours**	66
SL Length (minutes)	n. a.	**SL Grading System**	n. a.
Exam Type	Oral Exam	**Exam Language**	English
Exam Length (minutes)	20	**Exam Grading System**	One-third Grades
Learning Outcomes	Students can • create an overview of the signal processing chain for medical imaging. • explain the mathematical background of the reconstruction of CT images. • explain the basics of the physical relationships regarding X-rays. • enumerate the different generations of computer tomographs and explain differences. • apply the Fourier transform. • reproduce and explain the mathematical principles of two-dimensional reconstruction of CT images. • apply the algebraic approach to solving a reconstruction problem. • apply the static approach to solving a reconstruction problem. • highlight the differences between two-dimensional reconstruction and three-dimensional reconstruction. • sketch the transition from two-dimensional reconstruction to three-dimensional reconstruction.		
Participation Prerequisites	None		
Contents	• Signal processing (recapitulation of fundamental principles in signal processing) • Mathematical methods in image reconstruction and signal processing • X-Ray (fundamental principles, quantum statistics) • Computed Tomography (devices, current and past technology, signal processing, Fourier-based 2D and 3D image reconstruction, algebraic and statistical image reconstruction, image artifacts, technical and clinical applications, dose)		
Literature	• T. M. Buzug, *„Computed Tomography, From Photon Statistics to Modern Cone Beam CT“*, Springer-Verlag, Berlin/Heidelberg, 2008.		

	• T. M. Buzug, „*Einführung in die Computertomographie - Mathematisch-physikalische Grundlagen der Bildrekonstruktion*“, Springer-Verlag, Berlin/Heidelberg, 2004.		
Remarks	None		
Course 2: Numerical Methods			
Course Number		**Short Name**	NUM
Course Type	Lecture	**Form of Learning**	Presence
Lecturer	Botterweck		
Mandatory Attendance	☐	**ECTS Credit Points**	3
Participation Limit	60	**Semester Hours per Week**	2
Group Size (practical training, exercises, …)	None	**Workload (hours)**	90
Teaching Language	English	**Presence Hours**	24
Study Achievements („Studienleistung“, SL)	Flexible	**Self-Study Hours**	66
SL Length (minutes)	90	**SL Grading System**	One-third Grades
Exam Type	Written Exam	**Exam Language**	English
Exam Length (minutes)	90	**Exam Grading System**	One-third Grades
Learning Outcomes	The students are aware of typical numerical effects when solving engineering problems. They can map reasonable complex real-world situations to a mathematical model. They know of typical approaches toward a solution. They may use basic mathematical techniques as working tools.		
Participation Prerequisites	None		
Contents	Numerical error propagation. Stability and condition. Linear systems. Basic differential equations. Eigenvector decomposition. Ill-posed problems. Basic statistical distributions. Maximum likelihood approaches.		
Literature	• „*Introduction to numerical methods*“, MIT OpenCourseWare 2019: https://ocw.mit.edu/courses/mathematics/18-335j-introduction-to-numerical-methods-spring-2019/		

	• Frank C. Hoppensteadt and Charles Peskin, *„Modeling and simulation in medicine and the life sciences“*, Springer, 1992.
Remarks	None